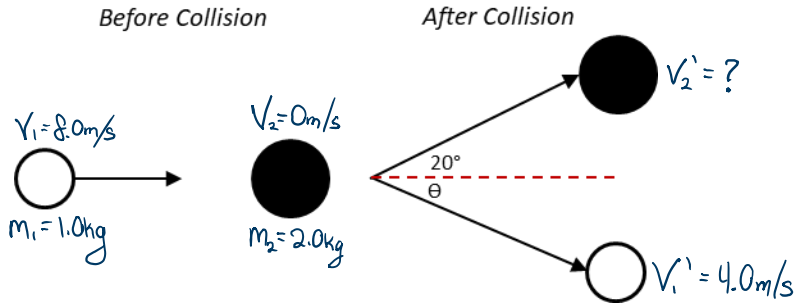
Lesson 3.5: Momentum in 2D

Unit 3: Momentum and Energy

Conservation of momentum still holds true in 2-dimensions

Example 1: 2D elastic collision solving by component and trig methods: A 1.0 kg ball travelling 8.0 m/s collides with a 2.0 kg ball at rest. After the collision, the 1.0 kg ball is travelling at 4.0 m/s at angle Θ with respect to the original path. The 2.0 kg ball is travelling at v_2' at 20° with respect to the original path. Find v_2' and Θ using the trig method.



$$p_{before} = p_{after}$$

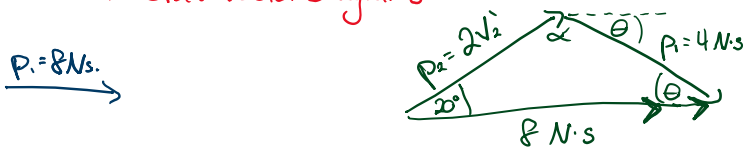
$$p_1 + \cancel{p_2} = p_1' + p_2'$$

$$m_1 v_1 = m_1 v_1' + m_2 v_2'$$

$$(1)(8) = (1)(4) + 2v_2'$$

$$8 = 4 + 2v_2'$$

*Draw vector diagrams:



Find α (sine law)

$$\frac{8}{\sin\alpha} = \frac{4}{\sin 20}$$

$$\sin\alpha = 2\sin 20$$

$$\alpha = \arcsin(2\sin 20)$$

$$\alpha = \cancel{43.2^\circ} \text{ or } 180 - 43.2^\circ = 136.8^\circ \checkmark$$

*8Ns is the largest side so pick largest ∠

$\Theta = 180 - 20 - 136.8^\circ$

$\Theta = 23.2^\circ$

$$\frac{2v_2'}{\sin 23.2} = \frac{4}{\sin 20}$$

$$v_2' = \frac{2\sin 23.2}{\sin 20}$$

$v_2' = 2.30\,m/s$

Find V_2' w cosine law:

$$c^2 = a^2 + b^2 - 2ab\cos C$$

$$p_1'^2 = p_2'^2 + p'^2 - 2p_2'p'\cos 20$$

$$(4)^2 = (2v_2')^2 + 8^2 - 2(2v_2')(8)\cos 20$$

$$16 = 4v_2'^2 + 64 - 32v_2'\cos 20$$

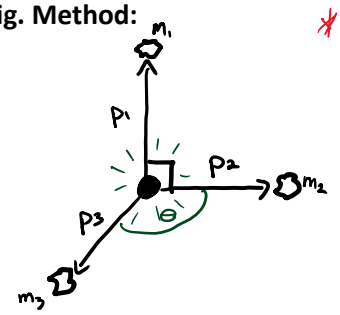
$$0 = 4v_2'^2 - 30.1v_2' + 48$$

$v_2' = \cancel{5.22\,m/s}$ or $2.30\,m/s$ ✓

$p_2 = 2(5.22) = 10.44\,Ns$ ✗ (only 8 available)

Example 2 – An explosion in 2D: A landmine explodes into three pieces in the horizontal plane. The 1st piece of mass 3.0 kg travels at 50 m/s. The 2nd piece of mass 2.0 kg travels at 70 m/s perpendicular to the 1st piece. Find the velocity of the 3rd piece if its mass is 2.5kg. Solve using both components and trig.

Trig. Method:

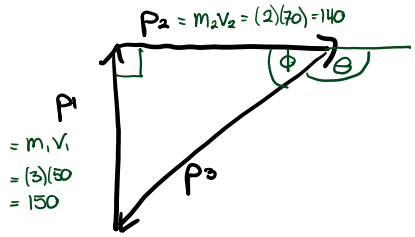


* In explosions $E_{explosion} = E_{kf}$ so energy is conserved.

$p_{before} = p_{after}$

$0 = p_{after}$

$0 = p_1 + p_2 + p_3$ 2.



$p_3 = \sqrt{150^2 + 140^2}$

$= 205.2\ N\cdot s$

$p_3 = m_3 v_3$

$v_3 = \frac{p_3}{m_3} = \frac{205.2}{2.5kg}$

$v_3 = 82.1\ m/s$

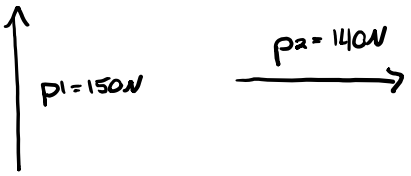
$\phi = \tan^{-1}\left(\frac{150}{140}\right)$

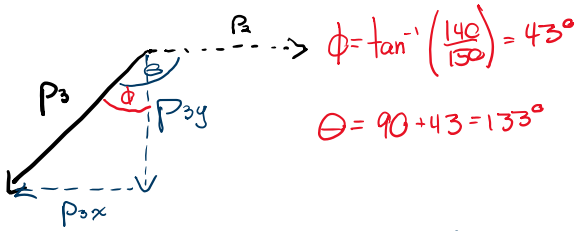
$\phi = 47°$

$\theta = 180 - 47 = 133°$

$V_3 = 82.1\ m/s$, 133° from 2nd piece

Component Method:





$\phi = \tan^{-1}\left(\frac{140}{150}\right) = 43°$

$\theta = 90 + 43 = 133°$

x-direction

$p_i = p_f$

$0 = p_2 + p_{3x}$

$p_{3x} = p_2$

$p_{3x} = 140\ Ns$

y-direction

$0 = p_1 + p_{3y}$

$p_{3y} = p_1$

$p_{3y} = 150\ Ns$

$p_3 = \sqrt{p_{3x}^2 + p_{3y}^2}$

$= \sqrt{140^2 + 150^2}$

$= 205.2\ Ns$

$V_3 = \frac{205.2}{2.5} = 82.1$

$V_3 = 82.1\ m/s$, 133° from piece 2.

Assignment: *Sander-Gore Pgs. 71-72 #1-5 AND Pg. 94 #8-9*